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PLANT DENSITY AND WEED MANAGEMENT EFFECT ON THE PRODUCTIVITY OF DRUM-SEEDED RICE (*ORYZA SATIVA* L.)

B N SANDEEP NAYAK[1], MD MUJEEB KHAN[2], K MOSHA[3] & P PRASUNA RANI[4]

[1]*Research Student, Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India*

[2]*Principal Scientist & Head (Retired) I W M Unit. RARS, Lam Farm, Guntur.*

[3]*Coordinator, DAATTC, Visakhapatnam, Andhra Pradesh, India*

[4]*Associate Professor, Department of Soil Science and Agriculture Chemistry, Agricultural College, Bapatla, ANGRAU, Andhra Pradesh, India*

ABSTRACT

Assessment of Plant density and weed management practices effect on the productivity of drum-seeded rice was studied. This study noted the impact in weed density and weed dry matter production subsequent to various procedures. Maximum reduction was observed by means of two cono weedings. The other methods also yielded results in the following order: two hand weedings (20 and 40 DAS), pre-emergence application of pendimethalin (@1 kg a.i. ha^{-1}) and post-emergence application of bispyribac sodium (@ 20 g a.i ha^{-1} and plant density of 71 hills m^{-2}). With reference to the plant density, 47 hills m^{-2} produced the maximum grain yield, with a record high of 4275 kg ha^{-1} following two cono weedings (W_3). Two hand weedings also produced relatively good output at 4142 kg ha^{-1}. The other weed treatment approaches adept at reducing weed production were pre-emergence application of pendimethalin @1 kg a.i. ha^{-1}, in addition to post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1}.

KEYWORDS: Drum Seeding, Cono Weeding, Pendimethalin, Bispyribac- Sodium, Hand Weeding

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INTRODUCTION

Over seven million people, comprising almost half of the world's population, are dependent on rice (*Oryza sativa L.*) for their staple food. Among these, Asia alone accounts for more than 90 per cent of rice consumption, as rice is a part of the staple diet in the region, including for the famished. In India, 65 per cent of the population include rice in their staple diet, and agriculturally, around 42 per cent of the food produced is rice. Worldwide, India and China hold prominent positions in rice cultivation. India is first in area under rice cultivation and second in production, for which China is in the lead.

In India, of late, the major shortcoming in farming is non-reimbursement in rice cultivation. This situation is amplified by increased cultivation costs, as farm labour is both scarce and costly during peak periods of farm operations. This has resulted in increased usage of direct-seeded rice, which yield better productivity and improve profits, helping to prevail over the increasing costs and scarcity of labour. However, hired labour for transplantation of the rice seedlings can result in inadequate plant density. This is considered as the main drawback of the method (Ram et al., 2006).

Drum seeding is a suitable replacement to overcome the aforementioned shortcomings. This method not only reduces labour requirement but also produces yield on par with transplanting method (Yadav and Singh, 2006). However, this method is riddled with serious problems, such as weed infestation, in comparison to the conventional puddled transplanted rice. The main cause for such a scenario is the size disparity between rice crop and weed plants and the lack of suppressive effect of standing water on weed growth.

Conventional methods of weed control such as hand weeding may not be possible in such areas where large labour force is needed at given a time. Dumping of high dosage of herbicides are not only affecting the soil flora and fauna but also reducing the production capacity of soil as well as plants by various ways. Low dosage and high efficacy herbicides not only are environment friendly chemicals but also economical in managing weeds.

MATERIALS AND METHODS

A field experiment entitled "Plant density and weed management effect on the productivity of drum-seeded rice (*Oryza sativa* L.)" was conducted at the Agricultural College Farm, Bapatla on sandy loam soil during *kharif* 2012.. The experiment grouped manual planting (20×15 cm) and five drum seeder spacings (20×7 cm, 20×10.5 cm, 20×14 cm, 20×17.5 cm and 20×24.5 cm) with varying rice plant densities (33, 71, 47, 35, 28 and 20 hills m^{-2}, respectively). The experiment also employed the following five weed management techniques: weedy check (W_1); hand weeding at 20 and 40 DAS (W_2); two cono weedings with modified cono weeder at 20 and 40 DAS (W_3); pre-emergence application of anilofos @ 0.375 kg a.i ha^{-1} and post-emergence application of 2, 4 D salt @1.0 kg a.i ha^{-1} at 25 DAS (W_4); and pre-emergence application of pendimethalin @1.0 kg a.i ha^{-1} and post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1} 30 DAS (W_5).

A strip plot design was used to conduct the trial. The experiment was replicated three times. The following are the details of the trial: rice variety used was NLR – 33358 (SOMASILA); fertilizer application was at the rate of 120:60:60 $N:P_2O_5:K_2O$ kg ha^{-1}; nitrogen application was at two split doses (at tillering and panicle initiation with basal dose); and application of phosphorous and potassium was as basal dose.

RESULTS AND DISCUSSIONS

Predominant weed flora in the experimental field were *Echinochloa colona, Echinochloa crusgalli, Cynodon dactylon* among grasses*, Cyperus rotundus, Cyperus difformis, Fimbristylis miliaceae* among sedges and *Eclipta alba, Ludwigia parviflora, Commelina benghalensis* among broad leaf weed in puddled condition.

Effect of Plant Density and Weed Management Practices on Weeds

.A rice plant density of 71 hills m^{-2} produced the maximum reduction in weed density and weed dry matter production. A similar impact was seen by certain weed management practices, such as two cono weedings at 20 and 40 DAS (W_3) and two hand weeedings at 20 and 40 DAS (W_2). Weed density and its dry matter production increased when weedy check treatment was applied. Bhowmick *et al.* (2000) and Walia *et al.* (2008) also reported a similar occurrence.

Except weedy check treatment, all the other methods successfully limited the growth of weeds. This was suggestive to the fact that there existed a significant relation between rice plant density and weed management. The highest rice plant densities were in the treatment combinations of W_2, W_3 or W_5 (Figure 1 and Figure 2).

The highest weed control efficiency (WCE) was recorded with plant density of 71 hills m^{-2} which was significantly superior compared to all other treatments. Among the weed management practices, weed control efficiency was significantly higher with weeding twice at 20 and 40 DAS with modified cono weeder. Among herbicidal treatments pre-emergence application of pendimethalin @ 1kg a.i ha^{-1} followed by post-emergence application of bispyribac sodium @ 20 g kg ha^{-1} was recorded significantly superior over application of pre-emergence application of anilofos @0.375 kg a.i ha^{-1} followed by post-emergence application of 2, 4 D Salt @ 1kg a.i ha^{-1}.

Effect of Plant Density and Weed Management Practices on Drymatter Production of Rice

In general there is linear increase in rice drymatter production up to flowering stage, there after it was stagnant. Among different plant densities, rice drymatter production was higher in thicker plant densities as compared to thinner densities. This increase was very prominent with higher drymatter production recorded in D_1 (71 hills m^{-2}) at maximum tillering (156.4 g m^{-2}), panicle initiation (871.9 g m^{-2}) flowering (1316 g m^{-2}), which was significantly superior to other plant densities. Thinner plant density treatment with mere 20 hills m^{-2} (D_5) recorded lowest rice drymatter production at maximum tillering (110.8 g m^{-2}), PI (481.7 g m^{-2}), and flowering (932.8 g m^{-2}) stages. The possible reason for this trend may be that increasing plant density increases LAI of crop which favours higher PAR interception resulting in higher drymatter production by crop. Lower weed infestation with higher plant densities further maintained the beneficial effects of increase rice drymatter production. These results confirmed the findings of Mahajan *et. al.* (2010) and Zhao *et.al*. (2010).

At panicle initiation, flowering and harvest stages manual (W_2) or mechanical (W_3) weeding methods performed better in increasing rice drymatter production. This might be owing to the fact that disturbing the soil by manual or mechanical means created well aerated atmosphere for better growth of rice root system which paved the way for better shoot growth due to better nutrient up take at the later stages of crop growth. These results are akin to the findings of Yadav and sigh (2006).

A significant interaction at most of the rice crop growth stages showed that initially high rice plant density with pre-emergence and post- emergence herbicide (W_5) combination resulted in higher rice drymatter production. During later stages of crop growth high plant density with mechanical and manual weeding resulted in higher rice drymatter production. At all the stages irrespective of variation in rice plant density the weedy check treatment showed lowest rice drymatter production. The probable reason for this might be severe crop-weed competition that resulted in weak and lanky rice plant growth thereby causing lowest rice drymatter production as compared to intervention of weed control by any of the weed management practices.(table 1 and Figure 3)

Effect of Plant Density and Weed Management Practices on Yield Attributes of Rice

Increased rice plant density resulted in increased productive tillers per unit area. The maximum tillers of 279 m^{-2} were seen in D_2 (47 hills m^{-2}), followed by D_1 (71 hills m^{-2}; 233 m^{-2}), D_3 (35 hills m^{-2}; 171 m^{-2}), D_4 (28 hills m^{-2};149 m^{-2}), D_5 (20 hills m^{-2};92 m^{-2}) and transplant D_6 (196 m^{-2}) (Table 1). Inter- and intra-plant competitions because of high plant density in D_1 and D_2 might cause mortality of normal tillers, resulting in lesser productivity, whereas reduced productivity in D_3 to D_6 was as a result of lesser plant density.

Cono weeding twice at 20 and 40 DAS (W_3) was the best weed management practice. This technique recorded the highest number of productive tillers (244 m^{-2}). This result was equivalent to those obtained by hand weeding twice at 20

and 40 DAS (W_2). Among all the weed management practices, weedy check (W_1) proved to have the least significant production (Table 1 and Figure 5).

Panicle length, test weight and total number of grains per panicle were significantly higher at a plant density of 20 hills m^{-2} over the rest. With regard to weed management treatments cono weeding twice at 20 and 40 DAS recorded more productive tillers, panicle length, test weight and total no. of grains $panicle^{-1}$. In chemical control pre-emergence application of pendimethalin and post-emergence application of bispyribac sodium (W_5) showed superiority in yield attributes (table 1 and Figure 4). Earlier Walia *et al*. (2008) and Yadav *et al.* (2009) also observed the effectiveness of bispyribac-sodium in controlling weeds without any phytotoxic effect on rice.

Effect of Plant Density and Weed Management Practices on Paddy Yield

When considering the rice plant densities, a medium level population (D_2; 47 hills m^{-2}) produced a better yield (3476 kg ha^{-1}). This finding was similar for all treatments except D_1, in which the plant density was 71 hills m^{-2}. The drum-seeded varieties (35, 28 and 20 hills m^{-2}) and the transplanted varity (33 hills m^{-2}) could not compete with D_2. However, the yield was similar to the plant density of 71 hills m^{-2} (D_1). The manual transplant (D_6) gave paddy of 3085 kg ha^{-1}which was on a par with the plant density of 71 and 35 hills m^{-2} drum-seeded rice with 3154 and 3060 kg ha^{-1},respectively. However, this increase stagnated beyond a certain point, as inter- and intra-plant competitions come into play. The struggle for available resources had a negative effect on the plant yield. This impact was successfully demonstrated by Mahajan *et al.* (2010).

Reduced plant density in D_4 and D_3 treatments (28 and 20 hills m^{-2}, respectively) was a result of the inadequate spacial occupation. To optimally utilize the in situ and external applied resources, the plant growth resulted in scarce density. This result, however, negates the phenomenon law of constant of Bond et al. (2005).

Twice cono weeding at 20 and 40 DAS (W_3), which was on a par with twice manual weeding 20 and 40 DAS (W_2) treatments (3570 kg ha^{-1}), recorded the highest paddy yield (3747 kg ha^{-1}) compared to all other weed management practices. Weedy check treatment (W_1) produced the least yield. Chemical weed management by pre-emergence application of pendimethalin @1 kg a.i ha^{-1} followed by post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1} at 25 DAS (W_5) was found better in increasing the yield over the pre-emergence application of anilofos @0.375 kg a.i ha^{-1} followed by post-emergence application of 2,4.D sodium salt @1 kg a.i ha^{-1} (W_4). The following is the order of increasing paddy yield on account of the various weed management methods in comparison to weedy check (W_1): cono weeding twice (W2) at 67.4 per cent, hand weeding twice (W3) at 66.4 per cent, application of pendimethalin followed by bispyribac-sodium (W5) at 63 per cent and application of anilofos followed by 2,4 D sodium salt (W4) at 56 per cent (Table 1). For long, sustained weed control with higher yield, sequential application of pre-emergence as well as post-emergence herbicide were more effective. The observations were in compliance with those of Bhowmick et al. (2000).

CONCLUSIONS

The best treatment combination was D2×W3 (4275 kg ha-1). This combination produced a noteworthy interaction between plant density and weed management. The subsequent best treatment combinations were D2×W2 (4142 kg ha^{-1}) and D1 ×W3 (4124 kg ha^{-1}). These combinations were superior to the transplanted paddy as well (Figure 6). The following conclusions were drawn through this study: with the diminished availability of manual labour, direct-seeded drum method is a far better option than the traditional system of transplanted paddies; medium to slightly higher plant densities

(above 33 hills m^{-2}) in combination with weed management can constrain the growth of first and second generation grassy weeds, as well as the broad-leaved ones; in addition, these combinations facilitate soil pulverisation, which enhances intermittent aeration and in turn rice productivity.

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APPENDICES

Table 1: Effects of Plant Density and Weed Management Practices on Weeds and Growth Character, Yields Attributes and Yield of Rice

TREATMENT		Weed Density (m^{-2})	Weed Dry Matter (g m^{-2})	Drymatter Production (g m^{-2}) of Rice	Number of Productive Tillers m^{-2}	Number of Grains Panicle^{-1}	Test Weight(g /1000 grain)	Grain Yield(kg ha^{-1})
RICE PLANT DENSITIES (D)								
D_1	20 ×7cm (71 hills m^{-2})	45.9	44.1	1338	233	75.7	18.6	3154
D_2	20 ×10.5cm (47 hills m^{-2})	50.9	50.9	1347	279	86.5	19.3	3476
D_3	20 ×14cm (35 hills m^{-2})	52.5	64.5	1166	171	94.4	19.2	3060
D_4	20 ×17.5cm (28hills m^{-2})	58.3	67.6	1089	149	96.6	19.8	2598
D_5	20 ×24.5cm (20 hills m^{-2})	60.9	81.9	1061	92	108.9	20.3	2419
D_6	Manual transplanting 20 ×15cm (33 hills m^{-2})	51.3	62.5	1221	196	101.7	19.8	3085
	SEm±	1.0	1.2	26	5	1.67	0.1	104
	CD (p = 0.05)	3.3	4.0	82	16	5.2	0.4	328
	CV (%)	7.6	8.0	8	6.7	7.4	2.9	14
WEED MANAGEMENT PRACTICES (W)								
W_1	Weedy check	124.9	94.2	668	119	50.4	18.4	1188
W_2	Hand weeding at 20 and 40 DAS	33.3	54.0	1501	235	114.9	19.9	3570
W_3	Cono weeding at 20 and 40 DAS	38.4	51.0	1522	244	132.5	20.2	3747
W_4	Anilofos @ 0.375 Kg a.i ha^{-1} (3-5 DAS) followed by 2, 4 D Salt 1.0 Kg a.i ha^{-1} at 20-25 DAS	42.5	61.7	1085	174	73.9	19.5	3004

W_5	Pendimethalin @1.0 Kg a.i ha^{-1} (3-5 DAS) followed by Bispyribac Sodium @ 20 g a.i ha^{-1} 30 DAS	32.3		50.5		1242			212		103.1		20.0		2353	
	SEm±	2.9		2.0		2929			4		0.6		0.1		601	
	CD (p = 0.05)	9.8		6.3		96			12		1.9		0.5		205	
	CV(%)	23.0		13.6		10			5.7		2.9		3.6		32	
	Interaction	W x C	C x W	W x C	C x W	W x C	C x W	W x C	C x W	W x C	C x W	W x C	C x W	W x C	C x W
	SEm±	3.7	2.9	9.2	2.6	140	7777	78	9	7.2	2.5	0.3	0.2	18	14
	CD (p = 0.05)	10.8	9.0	7.1	8.0	450	225	230	27	21.5	7.4	0.6	NS	53	43
	CV (%)	7.0.		6.7		8.0			5.8		5.5		2.5		15

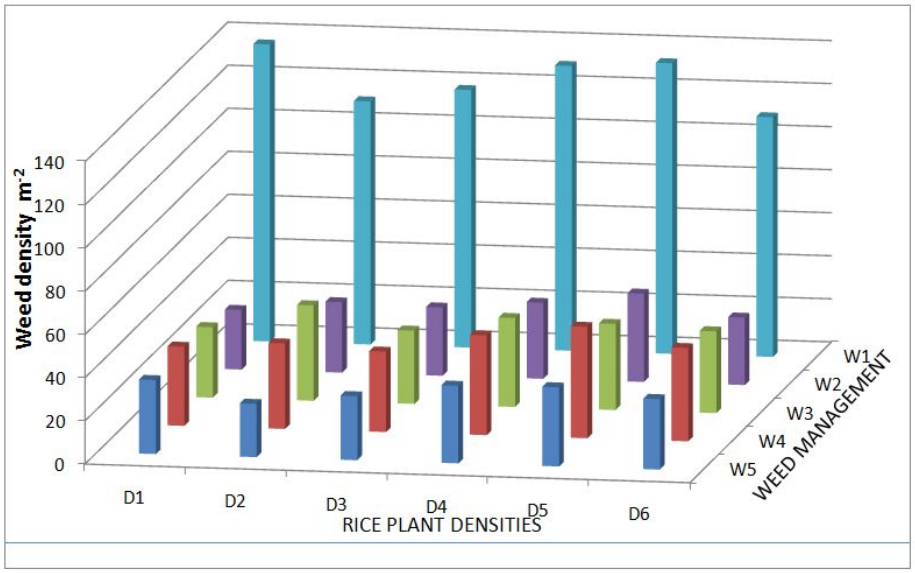

Figure 1: Weed Drymatter at Harvest as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice

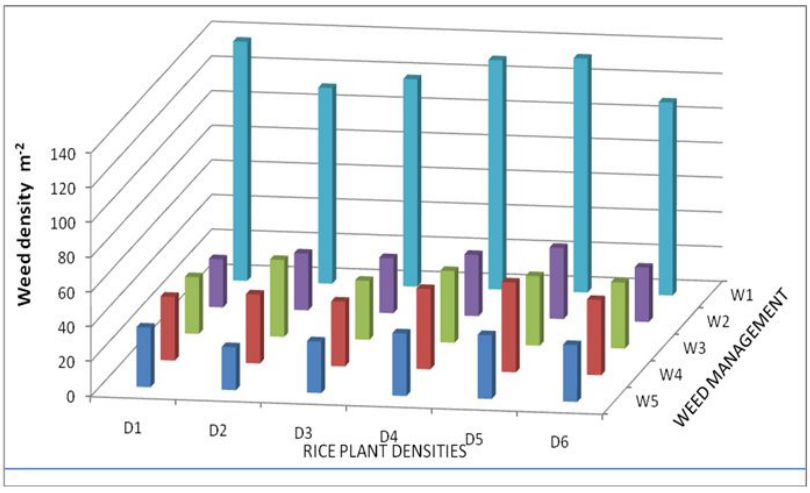

Figure 2: Weed Density at Harvest as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice

Note

D×W=densities means at the same level of weed management means

W×D= weed management means at the same level of densities means

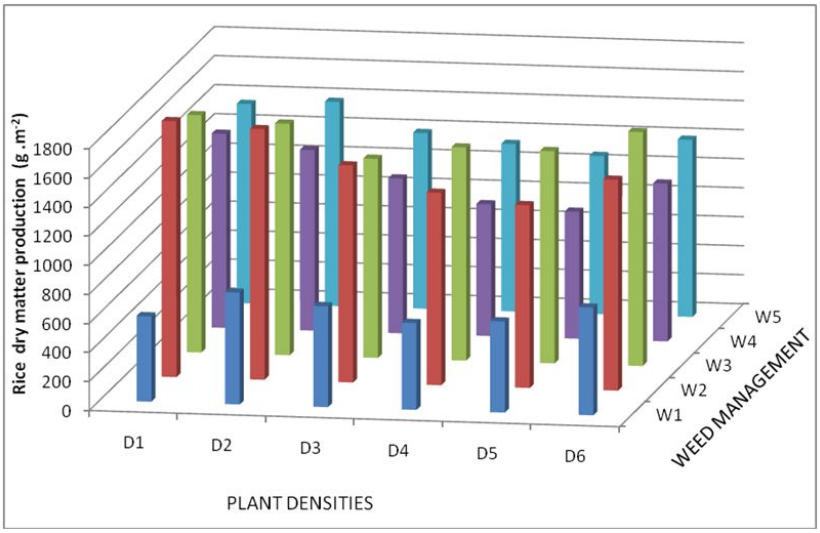

Figure 3: Rice Drymatter Production at Harvest Stage as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice

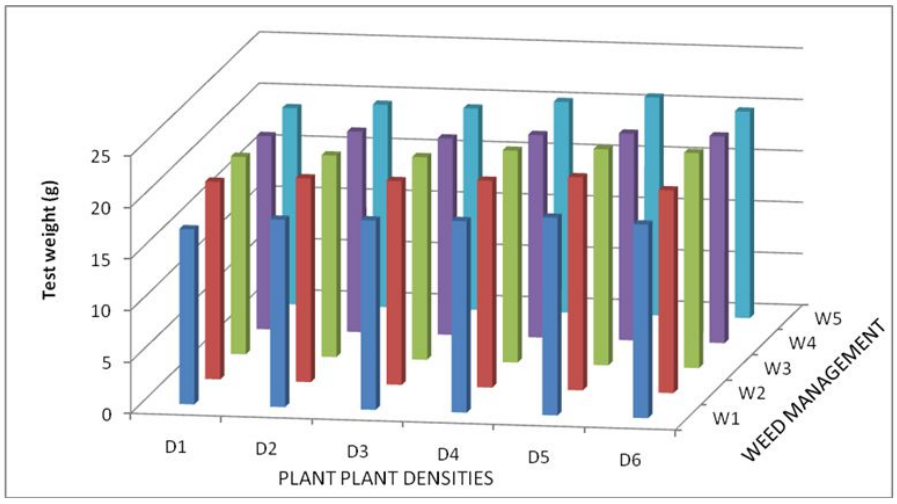

Figure 4: Test Weight as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice

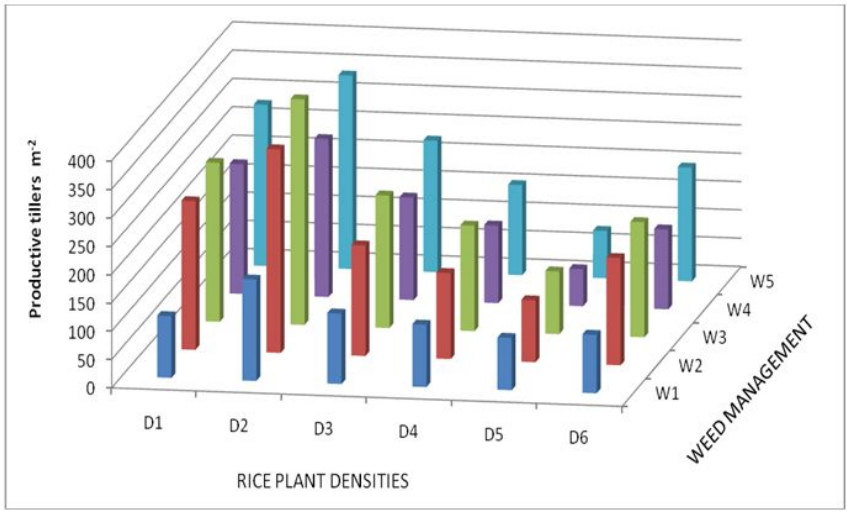

Figure 5: Rice Productive Tillers as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice

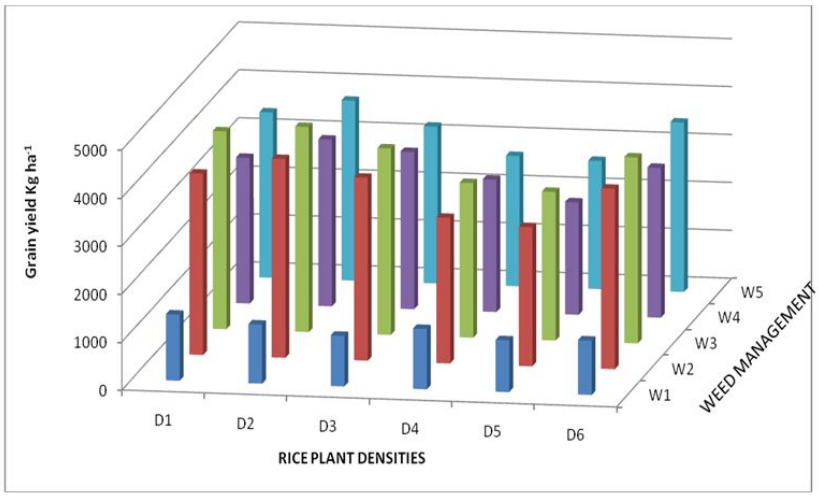

Figure 6: Grain Yield as Influenced by Varied Rice Plant Densities and Weed Management Practices in Drum Seeded Rice